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HYDRO POWER AND ENERGY PLANNING PROJECT (HPEP)

A STUDY OF THE VALUE OF LOST LOAD (VOLL) FOR GEORGIA

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1.0 EXECUTIVE SUMMARY

USAID Hydro Power and Energy Planning (HPEP) was requested to determine the value of lost load (VOLL) in the electricity market of Georgia, as it will apply within the framework of the cost-benefit template model for hydropower generation investment.

As the concept (and current value(s)) of VOLL doesn't exist in Georgia, the initial step HPEP undertook was an investigation of other countries' experience in order to develop an appropriate approach of estimation and to propose the value(s) of VOLL that would be applicable to the country.

This document was done in response to the request and it presents the results of the initial investigation.

The research and analysis were focused on the concept of VOLL, methodological approaches for estimation, the range of VOLL, factors affecting the estimates and its applications in electricity industries internationally.

Empirical studies that HPEP reviewed showed that the VOLL values are country-specific and there is no single estimate for a country. The VOLL varies significantly depending on the various specific factors such as the type of consumer (residential / commercial / industrial), time of the day (daytime / evening / night), the day of the week (weekday / weekend), the season of the year (summer / winter), the duration of an outage (10 min / 1hour / 4 hour / 8 hour) and whether the interruption is planned or not.

As the estimate of VOLL for one country reflects the preferences of customers in that country, it cannot generally be applied to a different country and would be a misleading proxy. Nonetheless, given several limitations such as nonexistence of detailed electricity sector data and no possibilities to conduct surveys at this time, using estimates from other countries as a proxy for Georgia was the only viable option.

In doing so, HPEP reviewed a variety of studies, covering both developed and developing countries in order to evaluate other countries' comparability with Georgia. The estimates we have seen reflected a huge difference between developing and developed countries' VOLL. The range we propose for CBA model is applicable for developing countries and varies from 1 to 5 $/kWh. However, these estimates should not be interpreted as the VOLL for Georgia; these numbers are guesses based on what we learned from the literature and is not free of criticism.

HPEP also considered lessons learned and best practices of methodological approaches for estimating VOLL and this report will give some guidelines and recommendations which may be useful for further work to arrive at an accurate VOLL estimate for Georgia in the future.

The report is structured as follows:
Section 1 presents the concept of the value of lost load and methods of estimations that are available in the present literature.
Section 2 reviews the applications of VOLL in electricity industry internationally.
Section 3 brings together the findings on VOLL from the studies we reviewed.

The last section discusses the case of Georgia and VOLL range we propose to the model.

2.0 THE CONCEPT OF THE VALUE OF LOST LOAD AND METHODOLOGICAL APPROACHES FOR ESTIMATION

2.1 What is VOLL

The value of lost load (VoLL) is defined as a measurement of the economic value of electricity that is not delivered to consumers as a result of a planned or unplanned outage. That is, the average willingness of consumers they are ready to pay to avoid an interruption. VOLL is expressed in dollars per each megawatt hour ($/MWh) of electricity not delivered.

VOLL has multiple dimensions and depends on the context in which it is assessed, including: the type of customers, the time of year, the time of week and day, the duration of an outage and availability of advanced warnings.

The costs that incur during outages can be divided into direct and indirect costs. Direct costs relate to immediate expenses that arise as a result of an outage. These costs include startup and shut-down costs, spoilage and additional wages, lost sales/revenues for small businesses and etc.

Indirect costs are costs for which no payment is made but are directly associated with the outage. This type of costs includes ‘annoyance’ or ‘inconvenience’ of customers. Given the difficulties in quantifying indirect costs of outage, in most cases VOLL is derived from direct cost. Nevertheless, measuring only the direct costs of outages is not sufficient to accurate estimate the full value of VOLL.

2.2 Measuring VOLL

In the present literature there are several ways how to measure cost of outage and subsequently, the VOLL in practice. These methods are:

- Revealed preferences
- Stated preferences
- Macroeconomic methods (or production function approach)
- Case studies

(1) Revealed Preference Method

A revealed preference method estimates the VOLL from observations on how respondents have behaved in the past. This method calculates expenses that customers incurred in purchasing back-up equipment or other mitigating approaches to avoid power outages.

Advantage of this approach is that it uses actual data which is generally reliable. However, there are several shortcomings to the method:

i) Countries with high reliability of supply (when outages are short and infrequent) the cost of back-up equipment is higher than the benefit from using it. Thus, VOLL is overestimated in such cases.

ii) There is a little evidence of investments in back-up generation in residential and small commercial sectors. Therefore, using the revealed preference approach for all types of customers will result inaccurate estimates.

(2) Stated Preference Method

A stated preference method uses customer surveys and interviews to measure the VOLL. Respondents are asked to evaluate hypothetical outages in the future. Two stated preference methods can be distinguished:

i) Contingent valuation method – respondents are asked directly how much money they are ready to pay (their willingness to pay -WTP) to avoid a specific type of outage.
ii) Conjoint analysis - respondents are asked to choose between several "choice scenarios" of supply reliability. Each hypothetical scenario has a particular price tag.

Once the surveys are completed, statistical analyses are done based on the responses in relation of features of outage, such as duration, time of outage, advanced warning and etc. VOLL estimates are then derived from the regression.

Shortcomings of this approach are:

i) Residential sector may give unreliable answers due to a lack of experience, so VOLL might be overestimated.
ii) Survey design and process requires time, a lot of effort and are expensive.

Stated preference methods provide a tool that researchers most prefer for the evaluation of reliability.

(3) Production Function Approach

A production function approach estimates VOLL as the ratio of Gross Domestic Product of a sector and the amount of electricity consumed by that sector. This gives the value this sector generates per kilowatt hour and is roughly equal to the value that would be lost in the case of an outage.

The production function method is the simple approach, as it requires data that are easily obtainable and therefore, is less time-consuming and costly compared to other methods. However, there are many shortcomings associated with the use of production functions to estimate the VOLL:

i. Estimations are done on an annual basis and thus, is not appropriate for evaluating the impact of hourly interruptions.
ii. Measures only direct costs of production (lost output) and does not account for additional damages due the electricity outages.
iii. Assumes that the time at which the outage occurs is not important.
iv. Duration of the electricity outage is not taken into account.

Therefore, the production function approach may not be sufficient to arrive at an accurate VOLL estimate(s).

(4) Case Study

A case study approach estimates the value of lost load using cost estimates from previous supply outages. This approach has number of advantages: they use actual and generally high accuracy data and deliver detailed information about different factors that influence the cost of supply outages. However, there are several drawbacks:

- The assumption here is that the past and the future are similar, which is not appropriate, given the economic and structural changes that take place over time. Thus, it could not be a representative for all types of interruptions in general.
- A case study is more expensive to conduct than the other three analyses.

A key conclusion from the literature we reviewed is that customer survey method provides more accurate estimates of VOLL than other methodological approaches, as it gives a possibility to estimate both direct and indirect costs incurred due a power outage.

3.0 APPLICATION OF VOLL

This section concerns the applications of VOLL and how the estimates can be used in practice. There are two potential ways of using: i) on planning side and ii) on operations side.

On the planning side, VOLL estimates can contribute to decisions on business plans, particularly it is used to analyze cost-benefit of investments in generation, transmission (distribution) networks. For example, in New Zealand the electricity regulatory entity conducted a survey of consumers to measure the VOLL, as it applies within the framework of investment analysis needed for changes in supply reliability.

On the operation side, VOLL can be used as:

i) **Criteria of generation adequacy**. That means the VOLL estimates are used to evaluate cost-benefit of reliability to derive a standard for capacity adequacy.

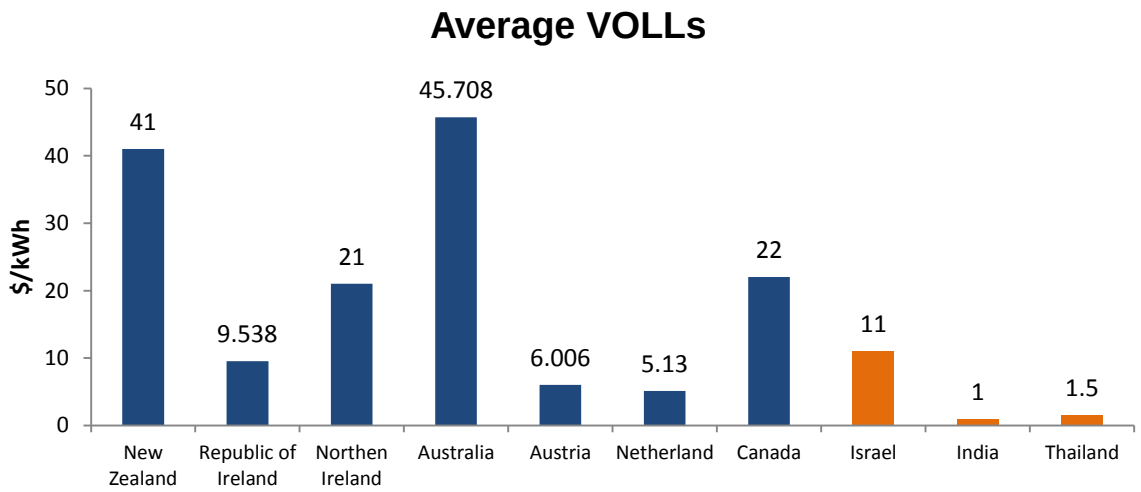
ii) **A pricing tool** – VOLL estimates can be used on wholesale electricity markets as a price cap, when supply outages occur during peak hours. “VOLL pricing” is expected to provide signals to suppliers and minimize the time of interruption, to encourage demand side (consumers) to reduce load and to provide incentives to invest ahead of time.

4.0 FINDINGS ON VOLL

In reviewing various studies of developed and developing countries we find big differences between VOLL estimates across and within countries. This section discusses the general observations on VOLL trends.

The graph below shows the estimates for 10 different countries we reviewed. Blue charts correspond to developed countries and orange – to developing ones. As the results show, VOLL’s vary between countries and are generally significantly higher for developed countries.

Graph 3.1 Average VOLL estimates for 10 countries



Methodological approaches as defined in Section 1 for estimating VOLL are different for the countries shown on the graph. This partially explains the difference between the estimates across these countries.

General findings we learned about VOLL trends are as follows:

(1) <u>VoLL varies across consumer classes</u>

The value of lost load differs substantially across customer classes, such as residential, small, medium and large commercial and industrial customers. In general, large industries are expected to have lower VOLLs than commercial and residential consumers, because in most cases industries are prepared for supply outages by investing in back-up generations. Below, in Table 3.1, a sectorial comparison based on the estimates of five countries is provided. Large industrial customers VOLLs are the highest in NZ and Australia. However, the opposite is true in the case of Republic of Ireland.

Table 3.1 VOLL estimates by sectors

Country	Average VOLL (US$/kWh)	Residential (US$/kWh)	Small Commercial & Industrial (US$/kWh)	Large Commercial & Industrial (US$/kWh)
New Zealand	41.269	11.341	30.874	77.687
Republic of Ireland	9.538	17.976	3.302	10.272
Australia	45.708	4.142	10.457	28.622
Austria	6.006	1.544		
Netherlands	5.13	23.24		

(2) VOLL is sensitive to the time of outage

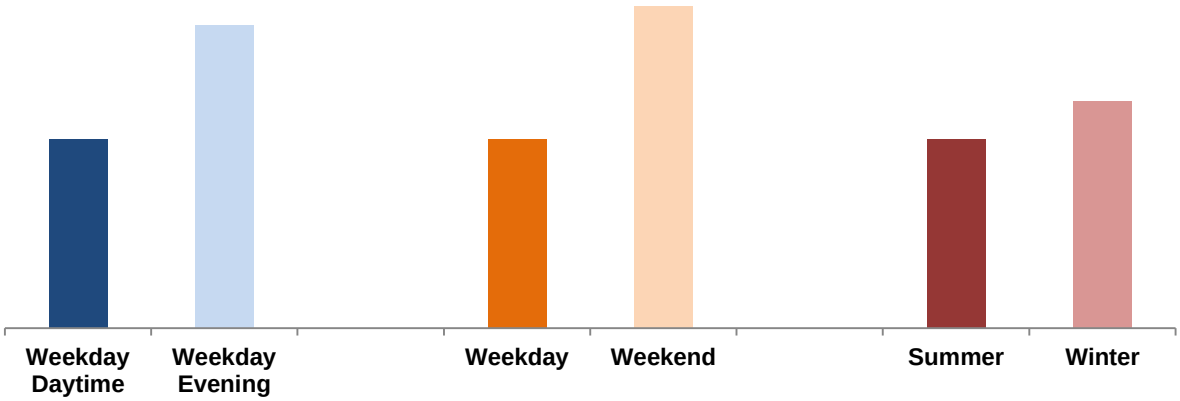
The estimates of VOLL vary significantly due to the following attributes of an interruption:

- The time of day.
- The day of the week.
- The season of year.

Weekday daytime outages are most valuable for commercial and industrial customers. Evening and weekend outages tend to be more inconvenient for residential customers; and winter and summer outages affect all customers relying on heating or air conditioning needs.

Graph 3.2 illustrates the three above-mentioned sets of attributes of the outage. The corresponding VOLL numbers are not charted on "y" axis as the graph does not reflect a specific country's example. Based on a set of studies reviewed, we derived general trends of VOLL for different sectors with respect to time attributes. Here, the graph illustrates the trends only for a residential sector.

Graph 3.2 General trends of VOLL for Residential Customers by Time Attributes



(3) VOLL depends availability of advance warning of interruptions

Advance notice of an interruption gives customers a chance to make adjustments and reschedule their activities that reduce the cost of an outage. For example, industrial firms will be able to shut down their operations to avoid damages of equipment or raw materials. Residential customers will be able to reduce their inconvenience by making alternate plans. Thus, the VOLL estimates tend to be lower for planned rather than unplanned interruptions.

(4) VoLL depends on the duration of outage

Relationship between VOLL estimates and duration of an interruption is not linear. In other words, VOLL for 1 hour outage does not equal to VOLL for a 10 minute outage multiplied by 6. The duration of the outage affects customers differently. For example, in some countries residential customers' VOLL increases

disproportionately with outage duration, while the opposite happens for some commercial and industrial customers where the VOLL estimates decrease relative to outage duration.

(5) VoLL is country-specific

The characteristics of customers and the activities they undertake differ significantly between countries. Empirical studies we reviewed showed that there is a great variation in the estimates of VOLL across countries, and there is little evidence that the VOLL applied in different countries are converging to a common figure. So, estimates of VOLL for one country cannot generally be applied to a different country and would be a misleading proxy.

(6) VOLL is substantially higher in developed countries

A possible reason, which could contribute in explaining the difference between the VOLL's for developing and developed countries, is that developed countries usually have a higher share of electricity consumption and are more dependent on power supply than electricity customers in developing countries. Therefore, they give a high valuation to supply continuity and the VOLL is much higher.

5.0 THE CASE OF GEORGIA

In this section we discuss the task assigned to HPEP to determine a value of lost load in electricity market of Georgia for the cost-benefit analysis of hydropower generation investment. Providing a single national figure was a challenging assignment, as the concept of VOLL and correspondingly, the current values do not exist in the country.

As an initial step, we started research and analysis of other countries experience in order to decide what can and should be done in Georgia. Empirical studies HPEP reviewed showed that a VOLL for a country reflects the preferences of customers of that specific country and would be a misleading proxy if it was used for a different country.

Nevertheless, given several limitations in Georgia, such as

- nonexistence of the concept of VOLL and current values,
- no similar work or research done before,
- no detailed electricity data to use the production function approach for estimation (simplified method), and
- no possibilities to conduct customer surveys at this time.

The only viable option in these circumstances was using the estimates from other countries as a proxy for Georgia. In doing so, we tried to evaluate a comparability of Georgia with the countries we reviewed. Finally, we did our choice based on the estimates applicable for developing countries. We do not (and cannot) provide a single (national) value of lost load. What we propose is the range that is derived based on estimates from developing countries and it varies between 1 and 5 $ /kWh.

Nevertheless, these estimates should not be understood as the VOLL for Georgia. These are only guesses based on what learnt from relevant literature.

In order to arrive at an accurate VOLL numbers, the country should conduct a comprehensive survey of electricity consumers.

6.0 CONCLUSION AND RECOMMENDATIONS FOR THE FUTURE

Given the task to estimate a single VOLL for Georgian customers for the purposes of evaluating economic impacts of investments in electricity generation market, HPEP investigated experience of other countries as an initial step of the process.

Various empirical studies we reviewed provided key findings on trends of VOLL both for developed and developing countries, best methodological approaches of estimation and implications of VOLL in electricity industries.

Studies revealed that a country has a wide range of values that reflect the preferences of customers in that specific country and are unlikely to be representative for other countries. Nevertheless, due to several limitations we faced in Georgia, the only option in the circumstances was using other countries' VOLL as a proxy for Georgia. We did our choice based on the range applicable for developing countries.

The estimates that HPEP proposes should not be interpreted as the VOLL for Georgian customers, as HPEP does not have the date to provide a single VOLL for the country, and specifically for the type of outage.

These numbers could be useful benchmarks only and could provide a basis on which to build an estimate of an accurate VOLL for Georgia in the future.

Arriving at accurate VOLL estimates for different customer classes and different types of outage requires a survey of end-users which is comprehensive, time consuming and costly. It will be an issue for future research, if the regulatory entity is interested in it.

As the VOLL is relevant to the regulatory body in order to regulate the reliability of electricity supply and monitor the operation of the market, HPEP presented the topic to GNERC (Georgian National Energy and Water Supply Regulatory Commission). The Commission has been interested in it and requested for further assistance. As the next step, HPEP will discuss the implications of VOLL in detail, what the experiences of other countries regulatory entities are and how GNERC should use the VOLL estimates for Georgia.

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